

CCD Astronomy

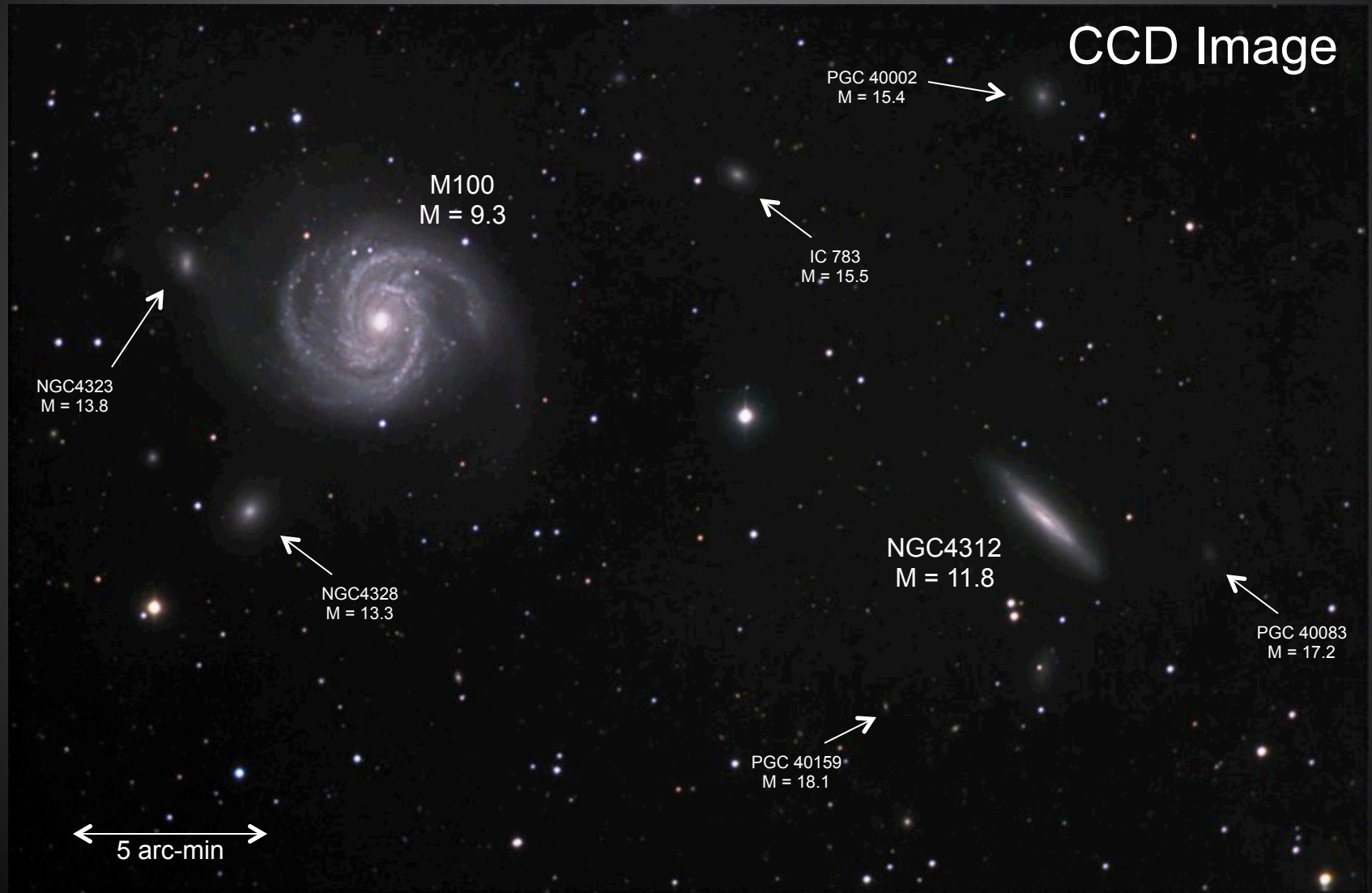
Automating the Process

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CCD Astronomy

- CCD imaging is visual astronomy
 - Those well travelled photons arriving from extremely distant objects are collected by the telescope optics and captured by the CCD in the camera
 - The CCD counts those photons at every detector (pixel) and sends the results to a computer
 - The computer processes those results and presents them on its display for your (and other's) visual enjoyment
- CCD imaging is a magical process
 - Greatly increases the sensitivity of the observer's eye
 - Brings out color and detail in deep sky objects that can't be seen any other way
 - Downside – it's not real time and refinement takes a little effort

CCD Magic



What Does it Take?

- Any amateur astronomer can make CCD magic happen
 - It takes is some extra equipment, some specialized software and an understanding of the CCD imaging process
- There are no closely guarded secrets – there are a few key things you need to *focus* on:
 - Long exposures with a sensitive camera
 - Absolutely precise focusing
 - Steady tracking equatorial mount
 - Accurate polar alignment
 - Good quality optics

Why Automate the Process?

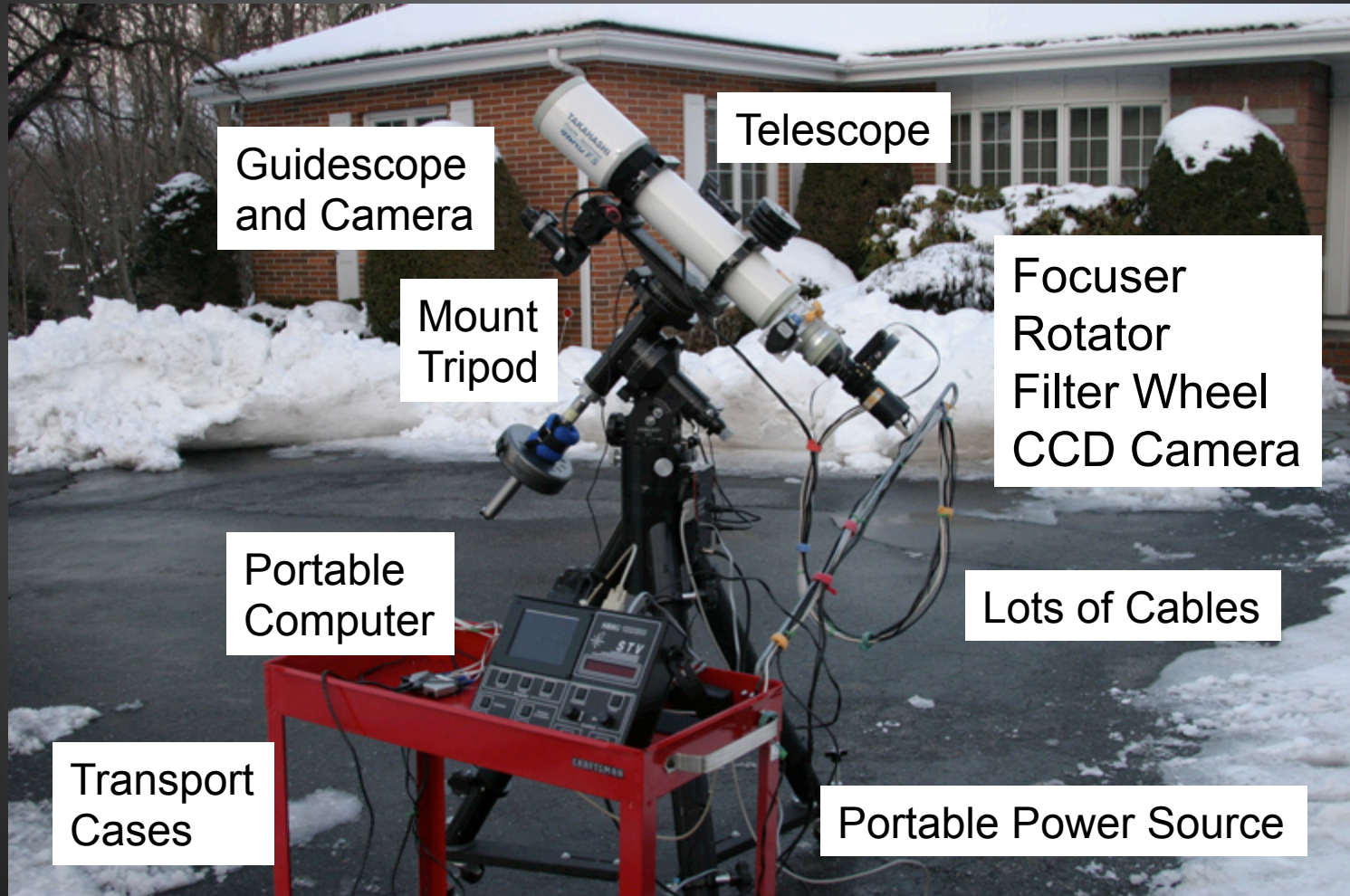
- So I can sleep through the night
 - Not really...
- More data = better images
 - Opportunities in this area are relatively rare
 - Would be great to take advantage of every dark, clear and calm night
 - Many good nights occur during the week, tough on those working or going to school



My Ideal Scenario

- Acquire Image Data at Home
- No Heavy Equipment to Lug Around
- Set Up and Ready to Run in Minutes
- Indoor Monitor and Control
- Totally Autonomous Operation
- High Reliability / High Success Rate
- Shutdown and Equipment Safe in Minutes

Typical CCD Imaging Rig



CCD Imaging – Basics

- Unpack and Setup
- Polar Align the Go-To Mount
- Build a Pointing Model
- Move to the Object
- Frame the Object
- Find a Guide Star
- Calibrate the Guider Program
- Select a Focus Star
- Move to the Focus Star
- Focus Precisely
- Move Back to the Object
- Frame of the Object (Final)
- Start the Autoguiding Process
- Take Exposures of the Object
- Stop the Autoguiding Process
- Safe the Mount and Power Down
- Tear Down and Pack Up

Periodic Refocusing

Cooling nighttime temperature causes focus to change – must refocus frequently to keep image crisp

- Stop Taking Exposures of the Object
- Stop the Autoguiding Process
- Select a Focus Star
- Move to the Focus Star
- Focus Precisely
- Move Back to the Object
- Adjust Pointing Until Object is Framed Just Right
- Start the Autoguiding Process
- Start Taking Exposures of the Object

Dreaded Meridian Flip



Before



After



The Flip



Meridian Flip Step-By-Step

- Stop Taking Exposures of the Object
- Stop the Autoguiding Process
- Move Telescope to the East Side of the Mount – Far Enough to Force the Mount to Flip
- If Self-Guiding, then Rotate Camera 180 degrees
- Move Back to the Object
- Reacquire Guide Star
- Adjust / recalibrate the Guider Program
- Perform a Refocus (Recommended)
- Start the Autoguiding Process
- Start Taking Exposures of the Object

Other Imaging Priorities

- Get Exposure Time on Other Objects
 - One Object Rarely in a Good Position All Night Long
 - Don't Want to Waste a Good Opportunity
- Acquire Calibration Frames
 - Bias
 - Darks
 - Flats (Dusk / Dawn / Artificial)

Streamline and Automate

- Install Pier and Permanently Mount Telescope and Imaging Equipment
- Remote Control All Critical Functions
 - Go-To Object / Coordinates
 - Focusing
 - Camera Rotation
 - Filter Selection
 - Camera Control
- Automation and Supporting Software

Pier Considerations

- Location
 - Horizon (Sky View)
 - Convenience
 - Sky Darkness
- Stability
 - Sturdy Enough to Take the Load
 - Isolated From Other Structures
- Power and Data Availability

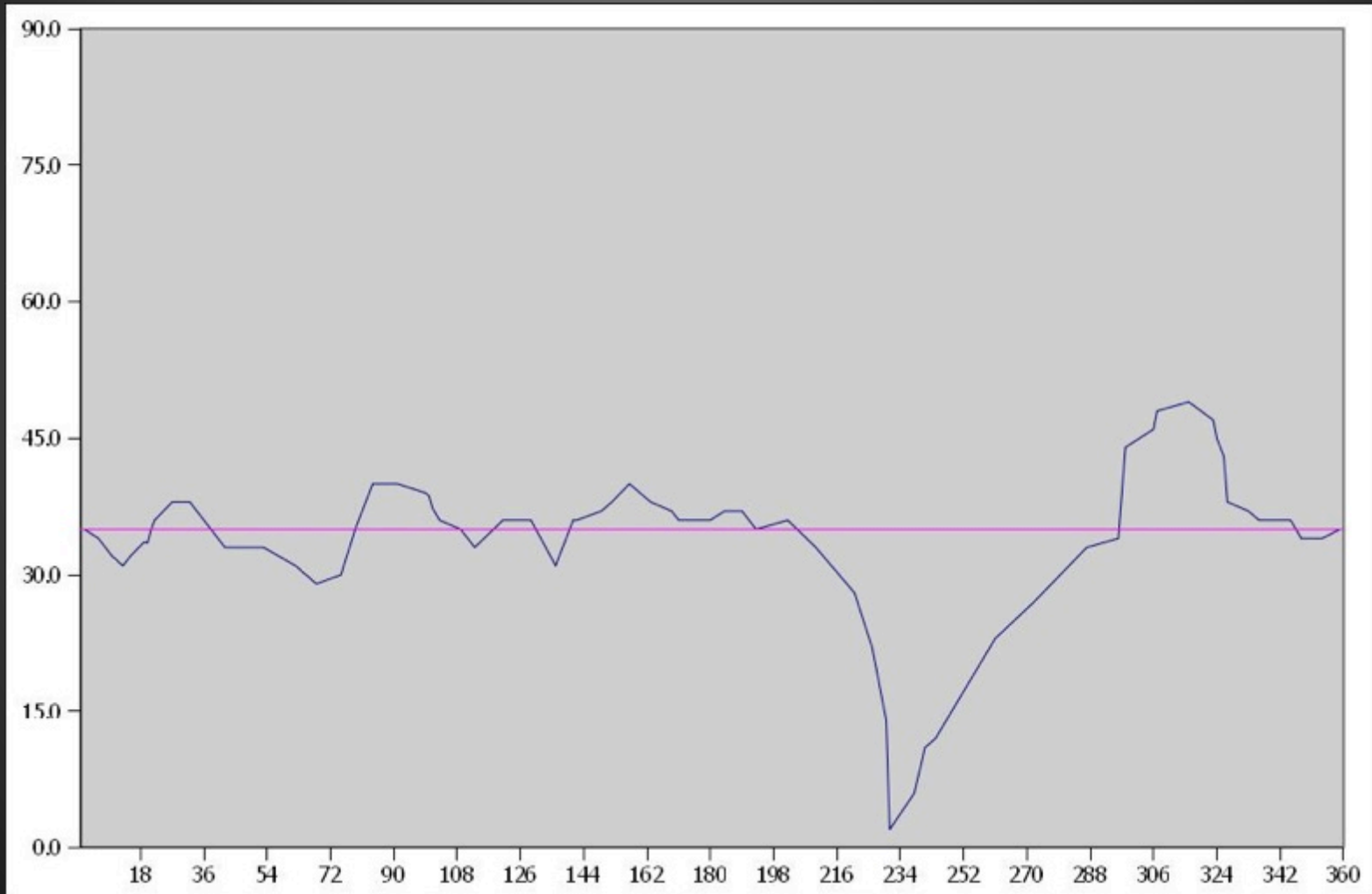
Installing My Pier



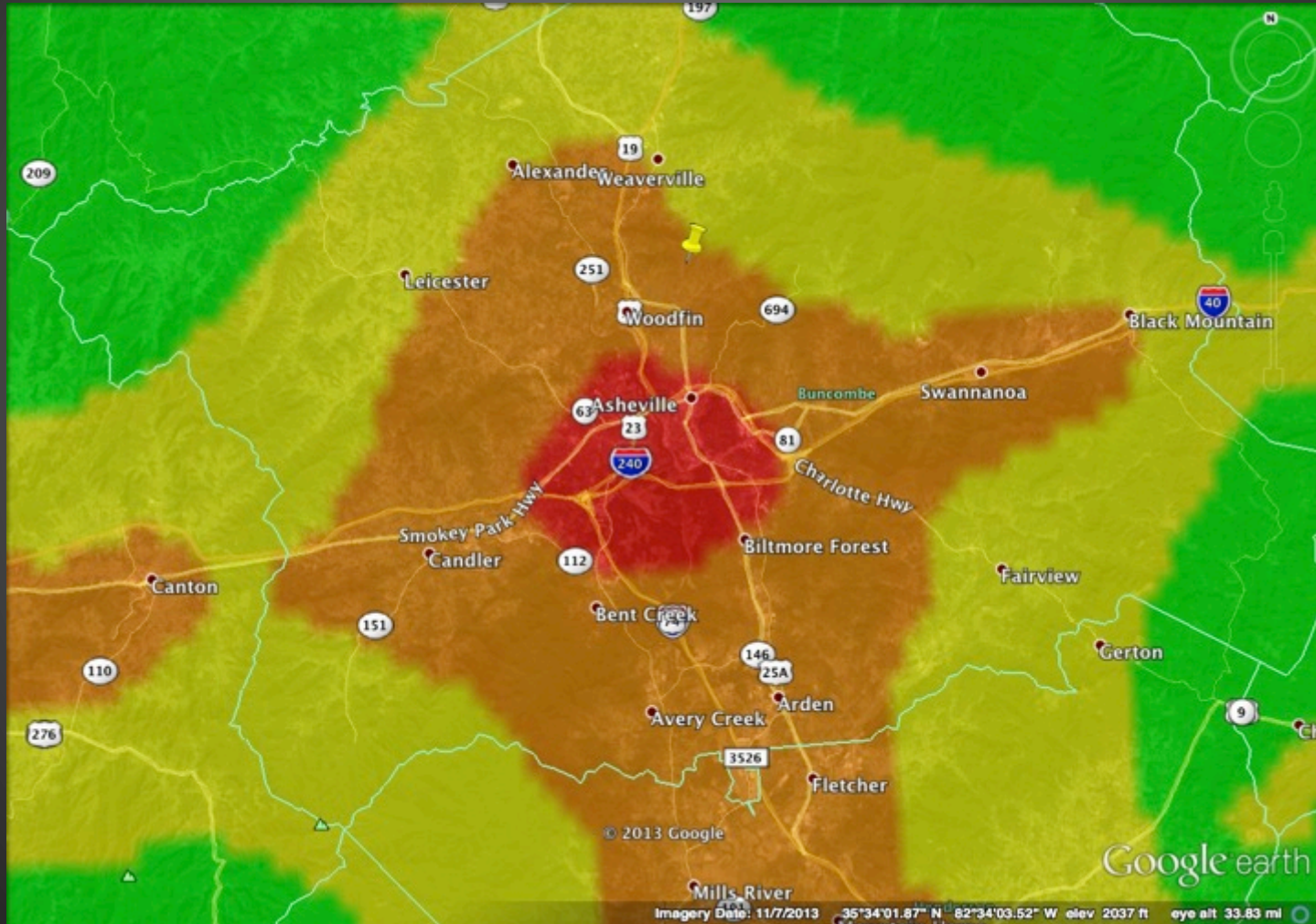
Pier Mounted Equipment



My Horizon



Sky Darkness

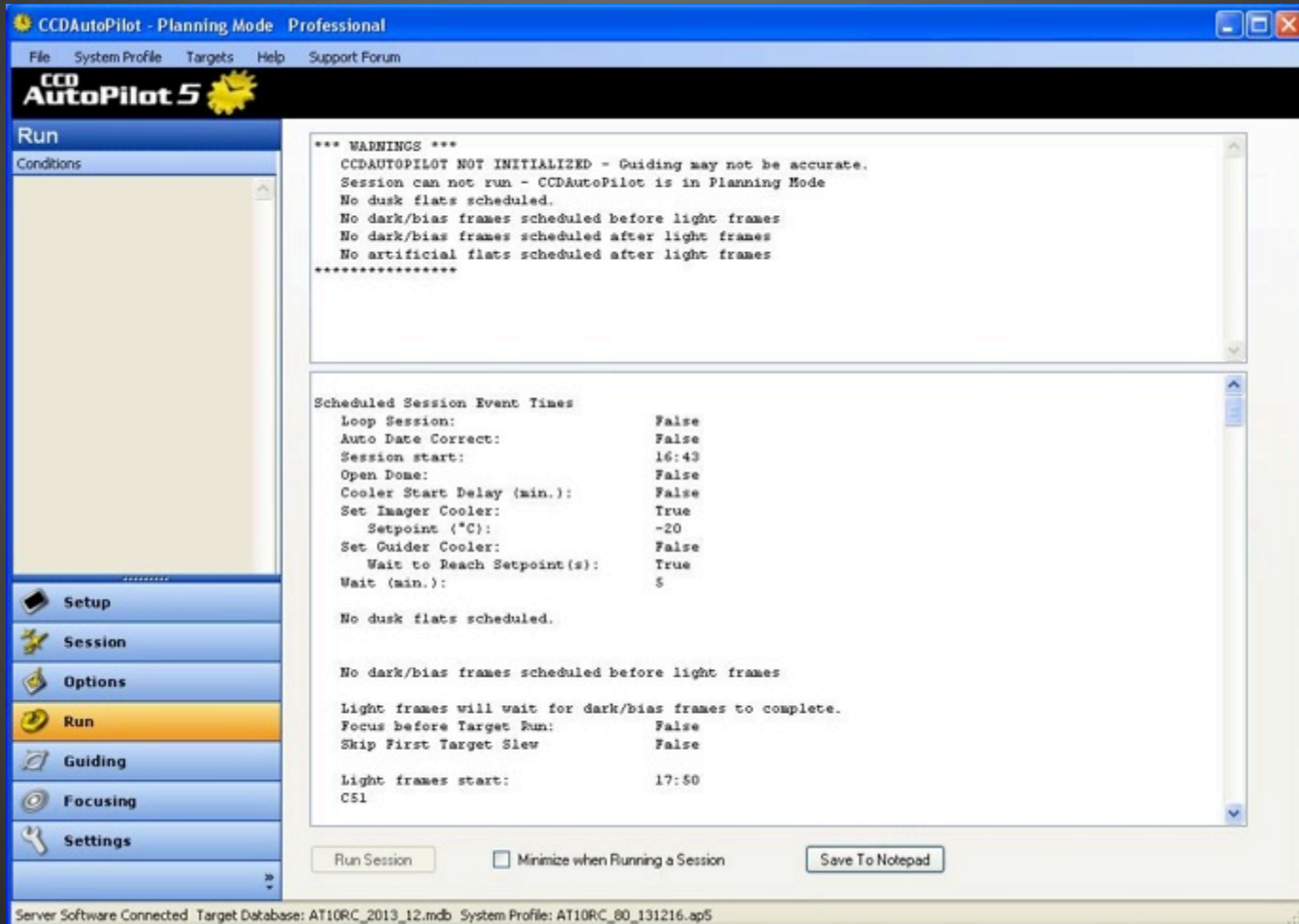


Remote Control Equipment

- ASCOM (Astronomy Common Object Model)
 - Astronomy Software and Equipment
 - Vendor Independent Plug-and-Play Compatibility

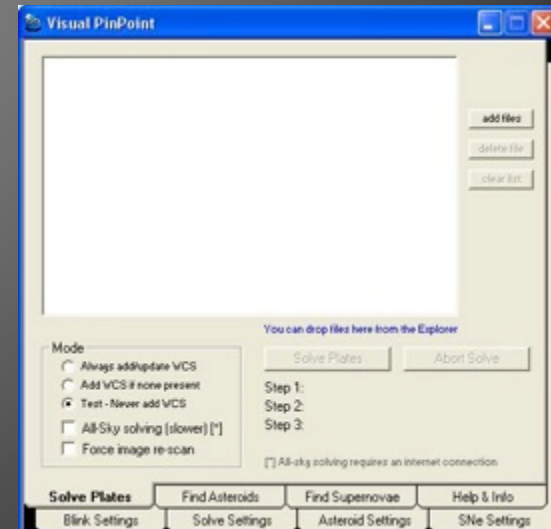
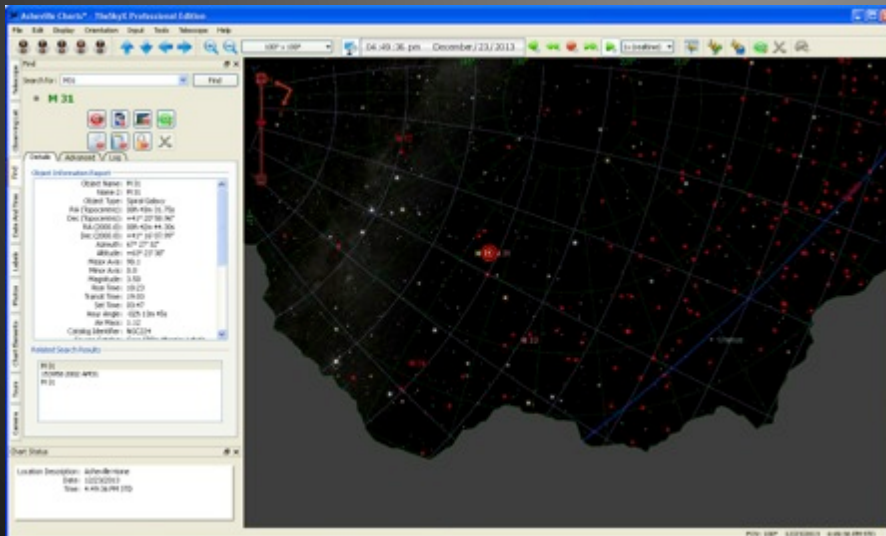
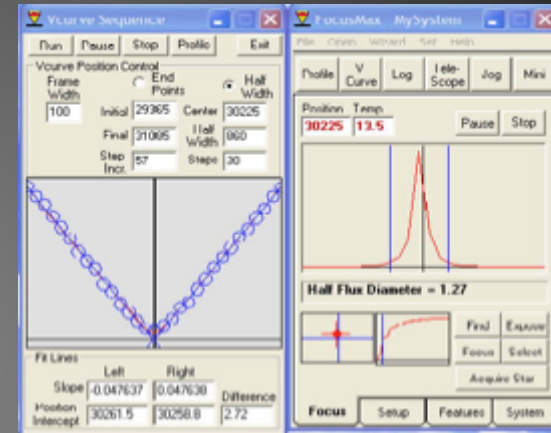


CCDAutoPilot



Supporting Software

- The Sky X
 - Find Focus Stars
- Pinpoint
 - Plate Solves
- FocusMax
 - Automatic Focusing



Working Together

- Automated Imaging System is Complex
 - Lots of Moving Parts
 - Many Independent Software Applications
- Supervisor (CCDAutoPilot) Expects Every Worker to Do as They Are Told
 - Demands Flawless Execution
 - Any Hang-Up and That Night's Session is Toast
- Takes Time to Get it Right
 - Lots of Critical Settings to Deal With
 - Months Before I Had Consistent Success

Planning and Post-Processing

- CCDNavigator
 - Find Suitable Objects to Image
 - Plan the Session in Detail
- CCDInspector
 - Identify the Good Frames and Toss the Bad
- CCDStack
 - Clean Up / Calibrate / Stack / Combine
- Photoshop
 - Stretch / Sharpen / Noise / Color / Refine

Good Planning Gets Results



CCD Imaging with Automation



~ 42 hours of exposure time between 8th and 20th of February 2010

Conclusion

- I am living the dream
 - Getting a chance to dream while I image deep sky objects
- Quantity and quality of the image data is fantastic
 - More than makes up for the less than optimal sky darkness at my home
- Now if there was only a way to control the weather...



M3
Globular Cluster